Photogrammetric and global positioning system measurements of active pāhoehoe lava lobe emplacement on Kīlauea, Hawai□ i

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Basalt is the most common rock type on the surface of terrestrial bodies throughout the solar system and—by total volume and areal coverage—pāhoehoe flows are the most abundant form of basaltic lava in subaerial and submarine environments on Earth. A detailed understanding of pāhoehoe emplacement processes is necessary for developing accurate models of flow field development, assessing hazards associated with active lava flows, and interpreting the significance of lava flow morphology on Earth and other planetary bodies. Here, we examine the active emplacement of pāhoehoe lobes along the margins of the Hook Flow from Pu‘u ‘Ō‘ō on Kīlauea, Hawai□ i Topographic data were acquired between 21 and 23 February 2006 using stereo-imaging and differential global positing system (DGPS) measurements. During this time, the average discharge rate for the Hook Flow was 0.01–0.05 m^3/s. Using stereogrammetric point clouds and interpolated digital terrain models (DTMs), active flow fronts were digitized at 1 minute intervals. These areal spreading maps show that the lava lobe grew by a series of

breakouts that broadly fit into two categories: narrow (0.2–0.6 m-wide) toes that grew preferentially down-slope, and broad (1.4–3.5 m-wide) breakouts that formed along the sides of the lobe, nearly perpendicular to the down-flow axis. These lobes inflated to half of their final thickness within ~5 minutes, with a rate of inflation that generally deceased with time. Through a combination of down-slope and cross-slope breakouts, lobes developed a parabolic cross-sectional shape within tens of minutes. We also observed that while the average local discharge rate for the lobe was generally constant at 0.0064 ± 0.0019 m^3/s, there was a 2 to 6 fold increase in the areal coverage rate every 4.1 ± 0.6 minutes. We attribute this periodicity to the time required for the dynamic pressurization of the liquid core of the lava lobe to exceed the cooling-induced strength of the lobe margins. Using DGPS-derived DTMs of the topography before and after pāhoehoe lobe emplacement, we observed that the lava typically concentrated within existing topographic lows, with the lobe reaching a maximum thickness of ~1.2 m above the lowest points of the initial topography and above reverse-facing slopes. Lobe margins were typically controlled by high-standing topography, with the zone directly adjacent to the final flow margin having average relief that is ~4 cm higher than the lava-inundated region. This suggests that irregularities ~25% of the height of the smallest breakout elements (i.e., toes) can exert a strong control on the paths of low-discharge pāhoehoe lobes, with stagnated toes forming confining margins that allow interior portions of flow to topographically invert the landscape by inflation.